P-8.7 Compare the value of time, length, and momentum in the reference frame of an object moving at relativistic velocity to those values measured in the reference frame of an observer by applying Einstein's special theory of relativity.

Revised Taxonomy Levels 2.6 B Compare conceptual knowledge

This topic was not addressed in physical science.

It is essential for students to:

- Understand the first postulate of special relativity: All the laws of nature are the same in all uniformly moving frames of reference.
- Understand the second postulate of special relativity: The speed of light in empty space will always have the same value regardless of the motion of the source or the motion of the observer.
- Understand that changes due to alterations of space-time are only seen in a frame of reference that is moving with respect of an observer's reference frame.
- Understand that time slows down in a moving system.
  The equation for time dilation is:

$$t = \frac{t_o}{\sqrt{1 - (v^2/c^2)}}$$

- Understand that as relativistic speed increases, contraction in the direction of motion increases. Lengths in the perpendicular direction do not change.
  Relativistic length contraction is stated mathematically:

$$L = L_o\sqrt{1 - (v^2/c^2)}$$

- Understand that the momentum of an object moving at relativistic speeds increases as the speed increases.
  Relativistic momentum increase is stated mathematically:

$$p = \frac{mv}{\sqrt{1 - (v^2/c^2)}}$$

  - The quantity m in the equation, called rest mass, is a constant even at relativistic speeds.

Assessment

As the indicator states, the major focus of assessment is to compare (detect correspondences). Students should compare the effects on time, length, and momentum of an object that is traveling at relativistic speeds.

Because the indicator is written as conceptual knowledge, assessments should require that students understand the "interrelationships among the basic elements within a larger structure that enable them to function together." In this case, assessments should show that students can compare the relationships between time, length, and momentum of an object traveling at relativistic speeds to those values measured in the reference frame of an observer.